Hydraulics:

Basic principles of physics

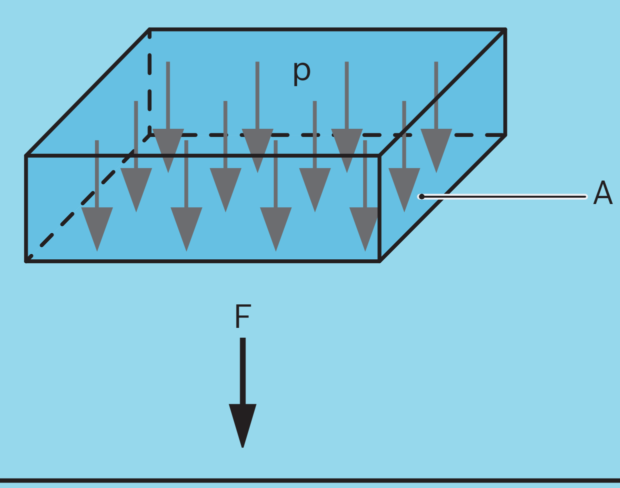
Hydrostatics - Pascal´s law

1 bar = 10 N/cm²
1 bar = 10^5 Pa
1 bar = 0,1 MPa

1 psi = 6894,757293168 Pa
1 bar = 14,49 psi

$$p = \frac{F}{A} \Rightarrow F = p \cdot A$$

$$1\,\mathrm{Pa} = 1\,\frac{\mathrm{N}}{\mathrm{m}^2}$$



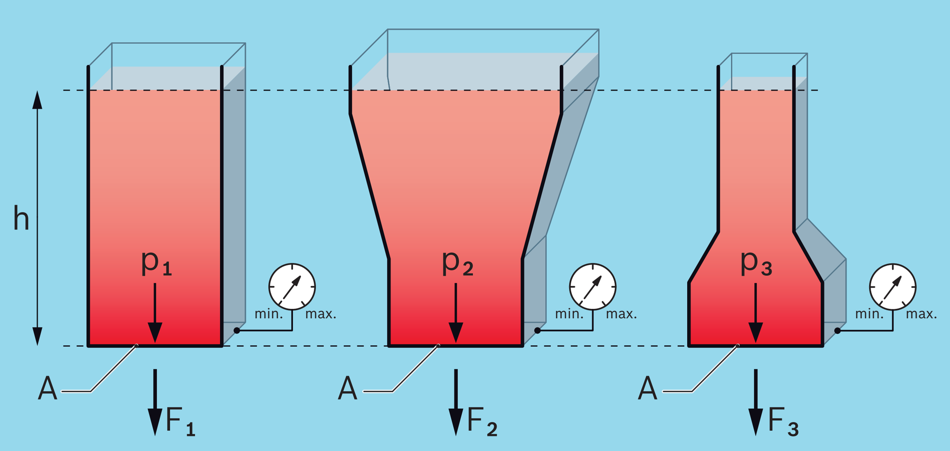
Hydrostatic pressure due to gravity

$p = \rho \cdot g \cdot h$

$p_1 = p_2 = p_3$

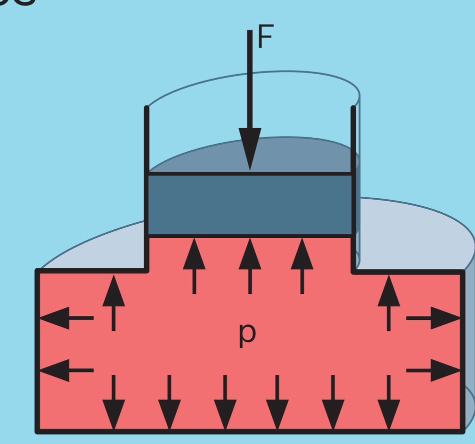
$F_1 = F_2 = F_3$

p Hydrostatic pressure
ρ Specific density of the fluid
g Acceleration due to gravity (9,81m/s²)
h Height of the fluid column



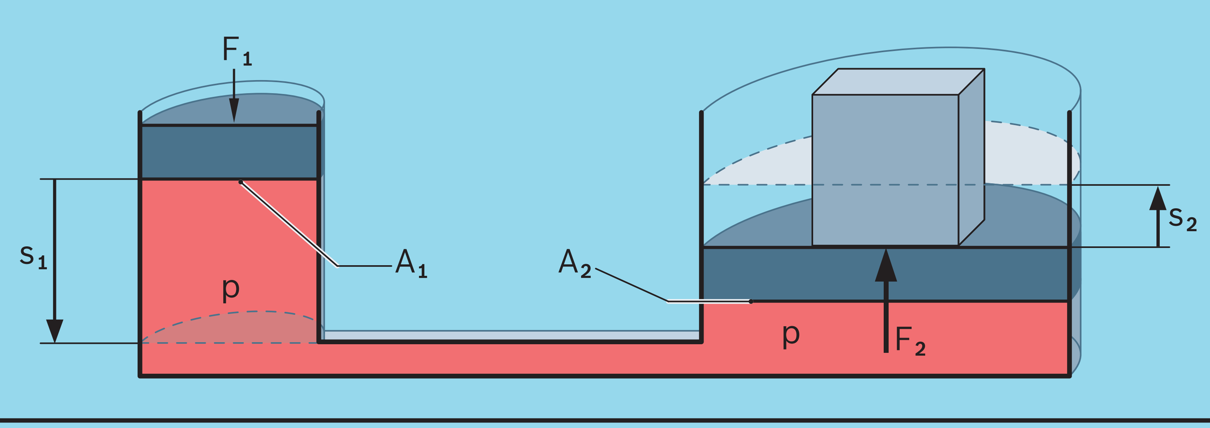
Hydrostatic pressure due to external forces

$$p = \frac{F}{A}$$



Force transmission

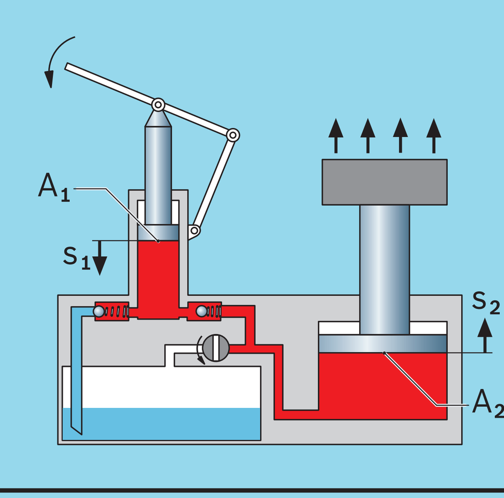
$$p = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$



Hydraulic lever rule

$\Delta V = A_1 \cdot s_1 = A_2 \cdot s_2$

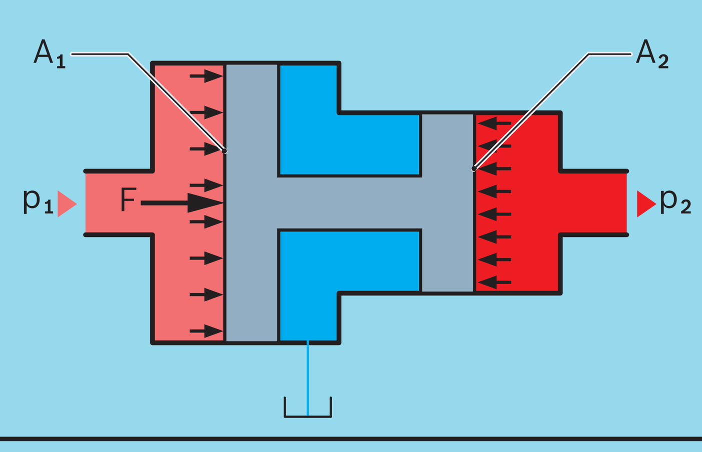
$$s_2 = s_1 \frac{A_1}{A_2}$$



Pressure intensification

$p_1 \cdot A_1 = p_2 \cdot A_2$

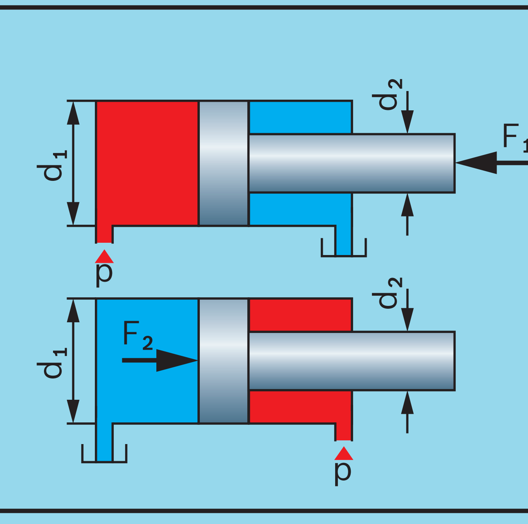
$$p_2 = p_1 \frac{A_1}{A_2}$$



Forces ratio: differential cylinder

$$F_1 = p\,\frac{\pi\, d_1^{\,2}}{4}$$

$$F_2 = p\,\frac{\pi\,(d_1^{\,2} - d_2^{\,2})}{4}$$

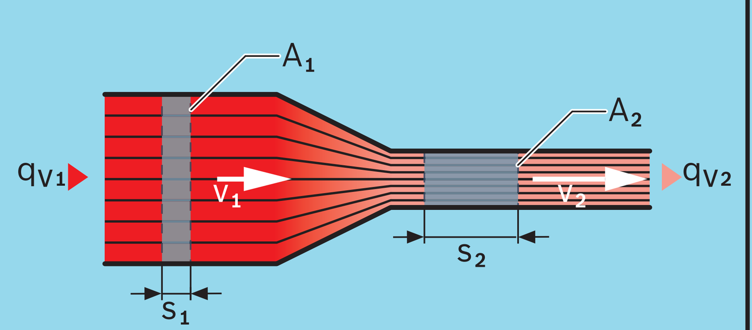


Continuity law

$A_1 \cdot s_1 = A_2 \cdot s_2$

$V_1 = V_2$

A_1, A_2 Cross-sectional areas
V_1, V_2 Flow velocity
s_1, s_2 Length
q_{V1}, q_{V2} Flow

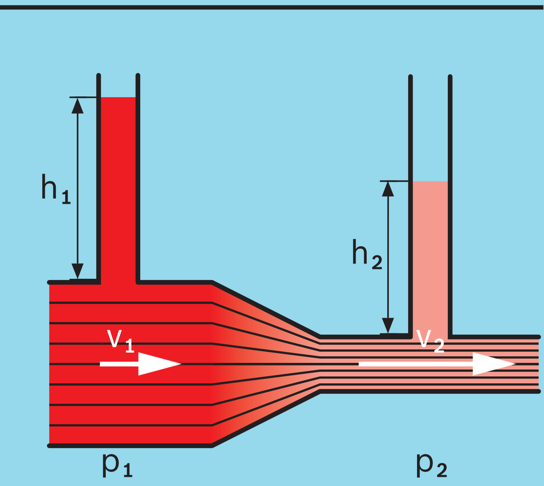


Bernoulli´s Principle

$$p \cdot V + m \cdot g \cdot h + \frac{m}{2} \cdot v^2 = const.$$

$$p + \rho \cdot g \cdot h + \frac{\rho}{2} \cdot v^2 = const.$$

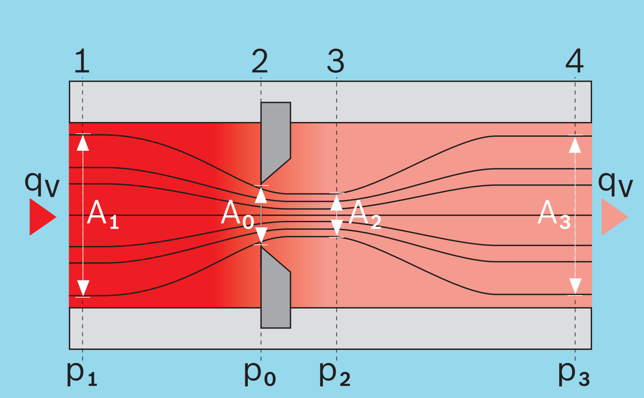
p Static pressure
ρ Specific density of the hydraulic fluid
g Acceleration due to gravity (9,81m/s²)
h Height in relation to the reference point
v Flow velocity



Orifice equation

$$q_V = \alpha_D \cdot A_0 \cdot \sqrt{\frac{2}{\rho} \cdot \Delta p}$$

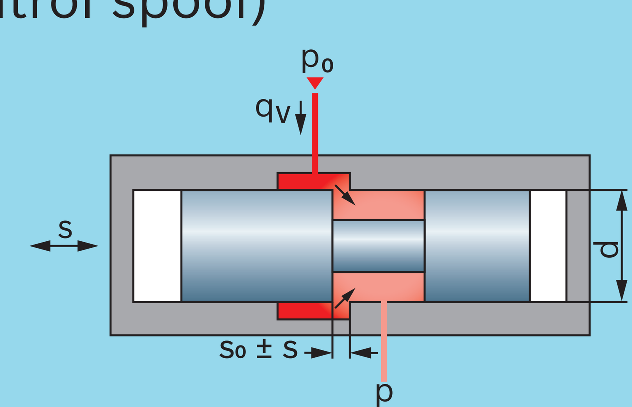
q_V Flow
A_0 Orifice cross-section
α_D Orifice contraction coefficient (orifice geometry)
ρ Hydraulic fluid density
Δp Pressure difference



Bernoulli´s Principle (example: control spool)

$$q_V = (s_0 \pm s) \cdot K \sqrt{p_0 - p}$$

$$K = \alpha_D \cdot \pi \cdot d \sqrt{\frac{2}{\rho}}$$



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